A Tool for Assessing Littoral Habitat Function for Salmon—The Tidal Habitat Model

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Abstract
The tidal habitat model, or THM, uses the indicator value assessment approach to rate quality of tidal marine and estuarine areas for various ecological functions including salmonid habitat (migration, feeding, osmoregulation, health, and predation). By using a scoring system to define baseline or existing habitat function within tidal areas and adjacent uplands, tidal areas can then be rated for their conservation, restoration, and mitigation potential.

Originally developed as the Snohomish Estuary Wetland Integration Plan (SEWIP) model by an interagency panel, the THM was revised in 2000 by an expert panel of agency and tribal representatives to ensure the model structure and output to reflect the best available science related to how salmonids use tidal habitat. The original SEWIP was applied to rate habitat enhancement, restoration, and mitigation potential, and to identify high priority restoration projects in the study area. In 2000, the model was used to identify and rate restoration projects in tidal areas within the Snohomish Estuary and Port Gardner. Actions that would be necessary to achieve a 20 percent increase in habitat function were identified and ranked. The THM is now being applied to 160 miles of shoreline in southern Puget Sound as part of Pierce County's salmon recovery planning.

Expanded Abstract

Introduction
Listing of several species of salmonids as "threatened with endangerment" under the U.S. Endangered Species Act has markedly raised the level of awareness among the scientific community, the general public, and elected leaders of the importance of estuarine and nearshore littoral habitats for salmonid population health. Groups planning salmon habitat restoration have recognized the importance of having a systematic inventory of the present condition of littoral habitats, a means of identifying potential restoration opportunities, and a means of rating the relative improvement in salmon habitat function that would result from a given restoration action.

The Tidal Habitat Model, or THM, uses the indicator value assessment (IVA) approach to rate quality of tidal marine and estuarine areas for various ecological functions including salmonid habitat (migration, feeding, osmoregulation, health, predation). By using a scoring system to define baseline or existing habitat function within tidal areas and adjacent uplands, tidal areas can then be rated for their conservation, restoration, and mitigation potential. Originally developed as the Snohomish Estuary Wetland Integration Plan model by an interagency panel, the THM was revised in 2000 by an expert Technical Group (TG) of agency and tribal representatives to ensure that the model structure and output reflect the best available science related to how salmonids use tidal habitat (City of Everett and Pentec 2001).

Model Description
The THM uses a modified IVA approach (Hruby **et al**. 1995); the model recognizes that truly quantitative measurement of the quality of habitat for specific ecological functions would require detailed knowledge of interactions of physical, chemical, and biological processes that can be gained through substantial field efforts over an extended period (seasons and years). To provide a useful and much needed tool for salmon habitat assessment over broad areas, the THM is based on the assumption that we know enough about environmental factors that affect the quality of habitat for salmonids to identify those factors (indicators), and rate the degree to which each indicator is associated with performance of the ecological function in question.

The THM is not process based; rather, it reflects existing habitat that is the result of continuing processes and those processes and human alterations that have happened in the past. The THM score for a reach of shoreline is considered to be related to habitat quality or productivity; when multiplied by area, the resultant numeric is considered related to salmonid abundance.

To develop the THM, the TG began by developing a simple conceptual model of environmental factors (indicators) believed to influence habitat function for salmon. We then developed a series of questions related to the presence of

each indicator in a reach of shoreline called an assessment unit (AU; Table 1). The TG assigned a specific numeric score depending on the degree or association between the indicator and salmon habitat function. When the indicator is present, the model assigns a score based on the perceived association of the indicator with good salmon habitat function if (1) the indicator is weakly associated with good habitat function; (2) the indicator is moderately associated with good habitat function; (3) the indicator is strongly associated with good habitat function. To reflect the most important aspects of salmonid habitat, the THM uses multipliers to represent the importance of certain indicators that have value extending beyond the geographic bounds of an AU, such as feeder bluffs, large woody debris sources, large areas of eelgrass or marsh, and deep tidal channels. To reflect stressors believed to reduce the quality of salmonid habitat, the THM uses decimal multipliers that were selected to be proportional to the degree of degradation of habitat function.

To apply the THM the area of interest is first divided into AUs of relatively uniform reaches of shoreline. This is accomplished using available information such as: shoreline aerial photographs (available from Washington State Department of Ecology) or other recent aerials; drift sector mapping (from Ecology); Washington Department of Natural Resources ShoreZone database. Field reconnaissance is then conducted to verify the AU boundaries and determine the presence or absence of indicators as shown in the THM score sheet (Table 1). The AU score is computed with a simple Excel spreadsheet. AU model score multiplied by area provides measure of functional area (productivity time's capacity) in "IVA-acres."

Applications

In 2000, the THM was used to identify and rate restoration projects in tidal areas within the Snohomish Estuary and Port Gardner. We mapped and scored 132 AUs covering approximately 80 miles of shoreline in the Snohomish Estuary and Port Gardner. We identified over 2,000 acres of area where restoration could be accomplished by restriction of existing log raft storage and used the THM to calculate the potential increase in salmon habitat function that would be gained. We identified over 5,000 acres where tidal habitat could be restored by breaching of dikes (Figure 1) and used the THM to calculate the potential increase in salmon habitat function that would be gained. We calculated that existing habitat function in the planning area could be increased by 20 percent with a modest level of effort, while allowing a reasonable development scenario. A scenario that would double the existing habitat function was also developed from feasible alternative actions.

In 2002, the THM was applied to 170 miles of shoreline in southern Puget Sound as part of Pierce County's salmon recovery planning. A range of habitat indicators was mapped and numerous restoration opportunities identified. For example, we provided data to map key habitat features like feeder bluffs and bulkheads (Figure 2) and eelgrass (Figure 3).

Summary

Once THM is accepted as a measure of the relative importance of an AU as habitat for salmonids, the possibilities are great. The model can be used in recovery planning to:

- Inventory the total existing salmon habitat in IVA-acres.
- Estimate past salmon habitat in IVA-acres.
- Design restoration actions.
- Assess restoration benefits that might be derived from a given project or a suite of actions and, thus, assess cost benefit of restoration alternatives.
- Establish restoration goals as an XX percent increase over YY years.

References

City of Everett and Pentec, 2001. Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (SEWIP). Prepared by the City of Everett, Washington, and Pentec Environmental, Edmonds, Washington.

Hruby, T., W.E. Cesanek, and K.E. Miller, 1995. Estimating Relative Wetland Values for Regional Planning. *Wetlands* 15(2):93-107.

Table 1. Field Inventory Sheet (partial).

SEWIP IVA for Estuarine or Marine Habitat

(This model assumes source of water is tidal fresh, brackish, or marine) | * BT-bull trout, CH-chinook, CO-coho, F-feeding, H-health/toxicity, M-migration, O-osmoregulatory, P-predator avoidance

Date **Surveyors** **On Site or Off Site? Circle**

AU #	**Supplement w/Aerials? Date and Type?**	Y/N	CH*	CO/BT*	Functions Addressed*	Comments
Hydrology					F, M, O	
1	AU has vernal or perennial freshwater stream or spring		3	3	F, O	
2a	AU is depositional (slow currents, low wave action) over 25% of littoral area		2	2	F	
2b	AU is depositional (slow currents, low wave action) over 50% of littoral area		3	3	F	
3	AU has refuge from high velocities (e.g., during max. ebb)		3	3	M, P	
4a	AU contains a natural tidal channel wetted at MLLW		X1.5	X1.3	F, P	
4b	AU contains tidal channel wetted at MSL (i.e., shallow drainage)		2	2	F, P	
5	Tidal channel is dendritic or highly sinuous		3	3	F, P	
Water Quality						
6a	Fresh water only (salinity <0.5 ppt)		1	3	F	
6b	Oligohaline to Mesohaline (sal. variable: often 0.5 to 5 ppt, but can range to 18 ppt)		3	3	F, O	
6c	Polyhaline (sal. typically 18 to 30 ppt)		1	1	F, O	
7a	Temp/DO meet criteria for salmonid health during major use periods		2	2	H	
7b	Temp/DO meet criteria for salmonid health at all times		3	3	H	
Physical Features						
	Vascular plant/mud (or sand) flat boundary (vegetated/unvegetated boundary)					
	Shoreline complexity					
8a	Ratio of length of MHHW boundary to width at MLLW >3 (include islands)		3	3	F, P	
8b	Ratio of length of MHHW boundary to width at MLLW 1.2 to 3 (include islands)		2	2	F, P	
8c	Ratio of length of MHHW boundary to width at MLLW <1.2 (include islands)		1	1	F, P	
Exposure						
9	AU is sheltered from waves		2	2	F	
Slope						
10a	Slope of substrate in littoral zone >10h:1v (i.e., low gradient)		3	3	F, P	
10b	Slope of substrate in littoral zone <10h:1v but >5h:1v (i.e., moderate)		2	2	F, P	

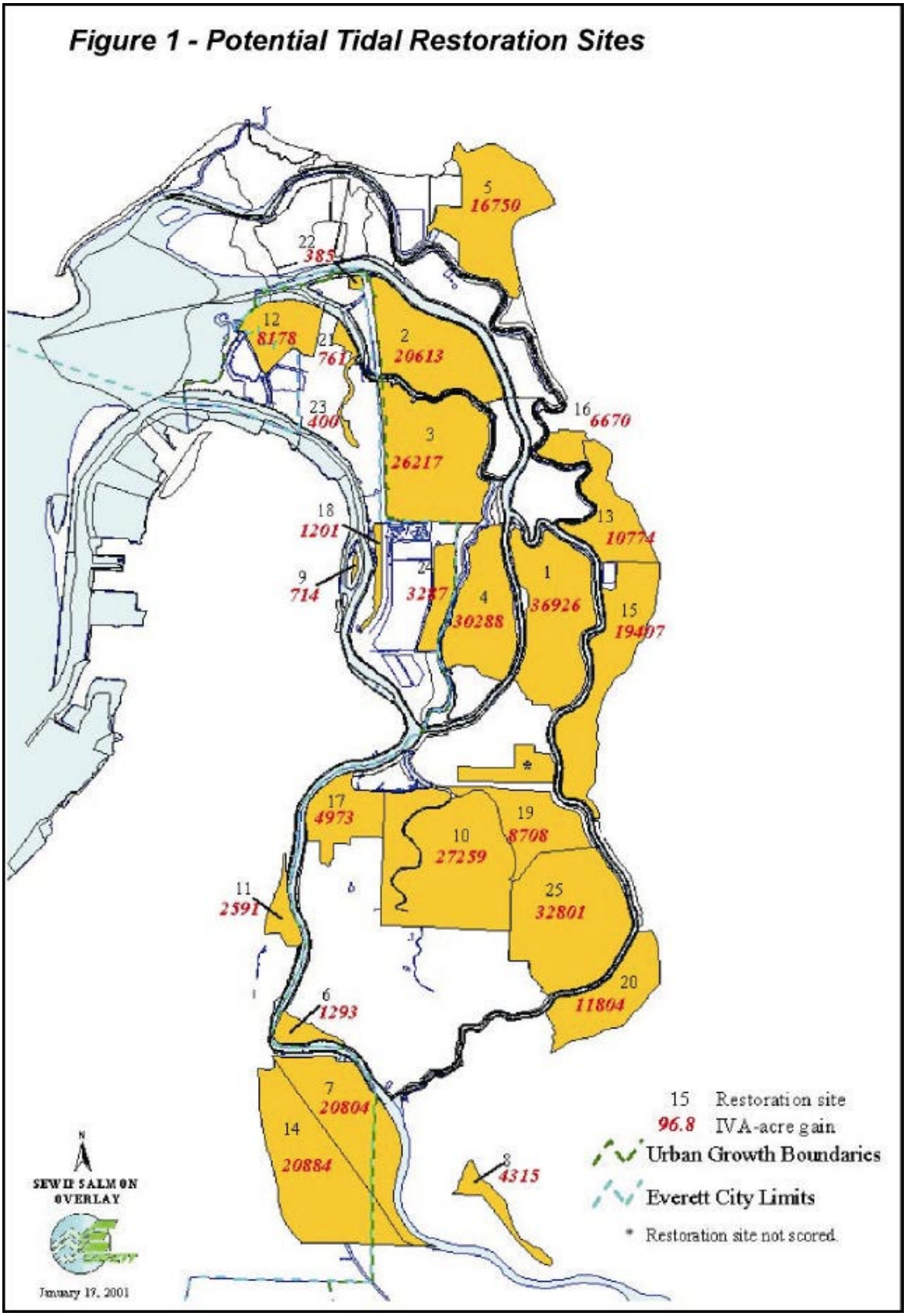

Figure 1. Potential Tidal Restoration Sites.

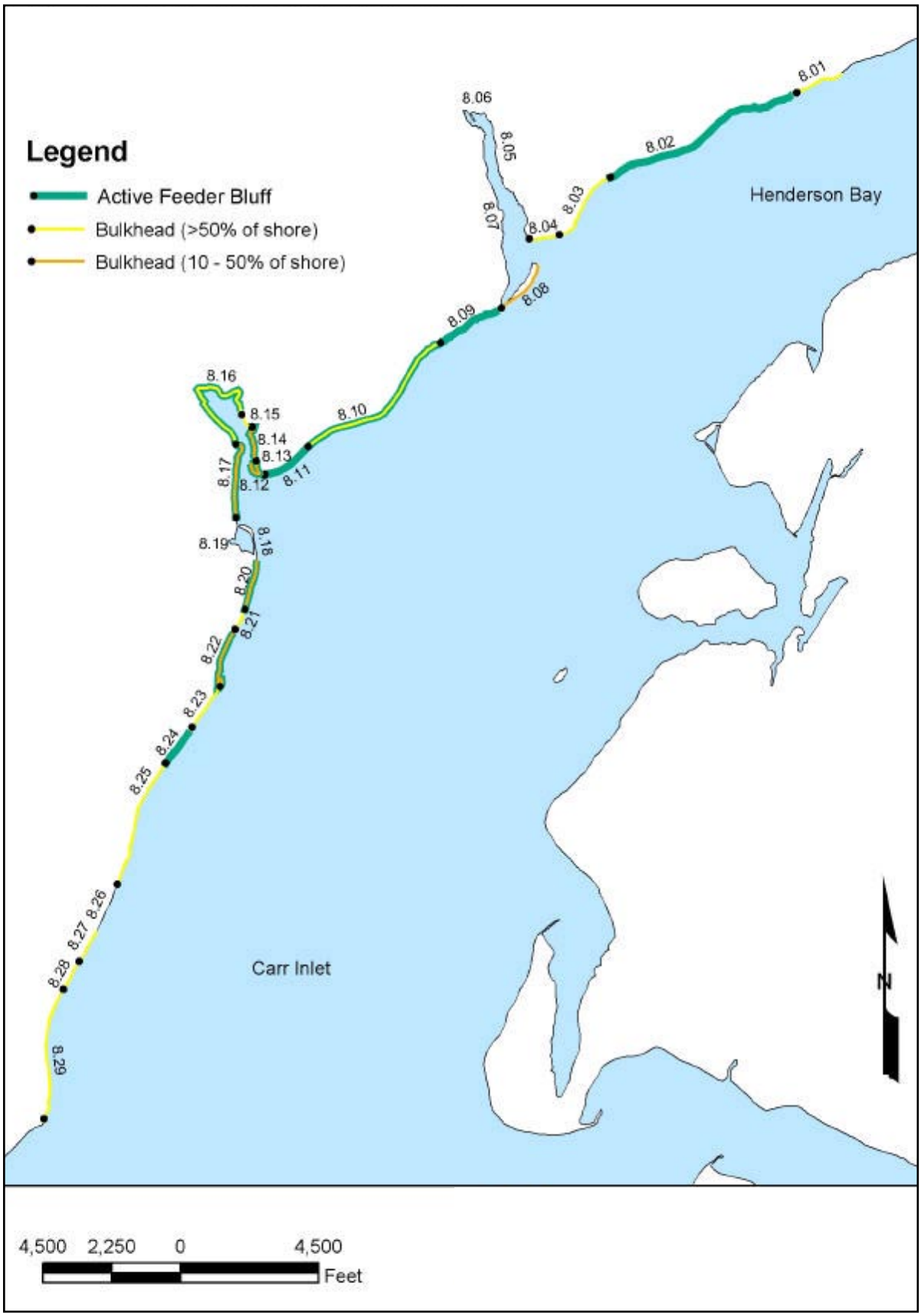

Figure 2. EMU 8 Feeder Bluffs and Bulkheads.

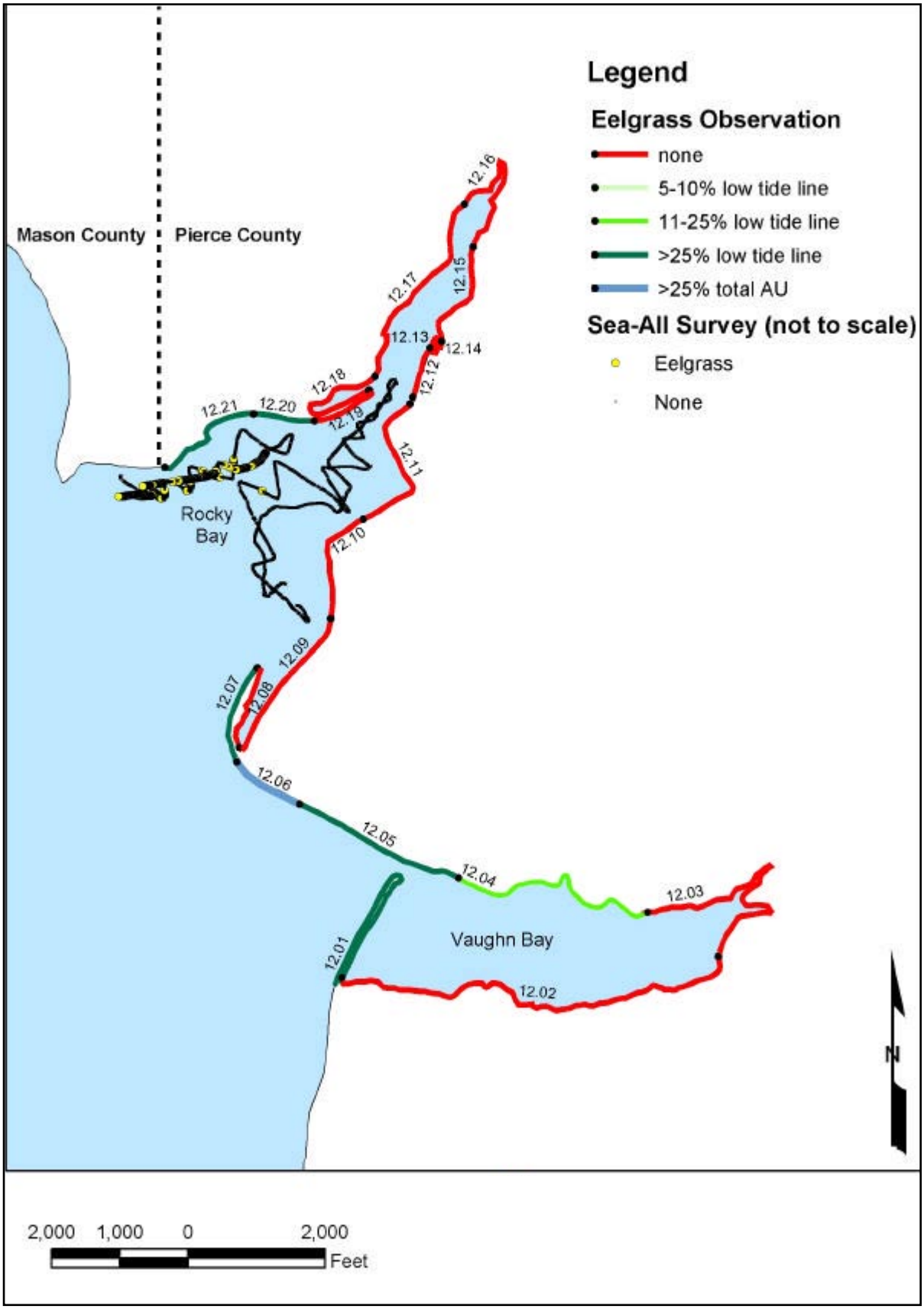

Figure 3. EMU 12 Eelgrass Observations.